The US DOE Solar Energy Grid Integration Systems Program "SEGIS"

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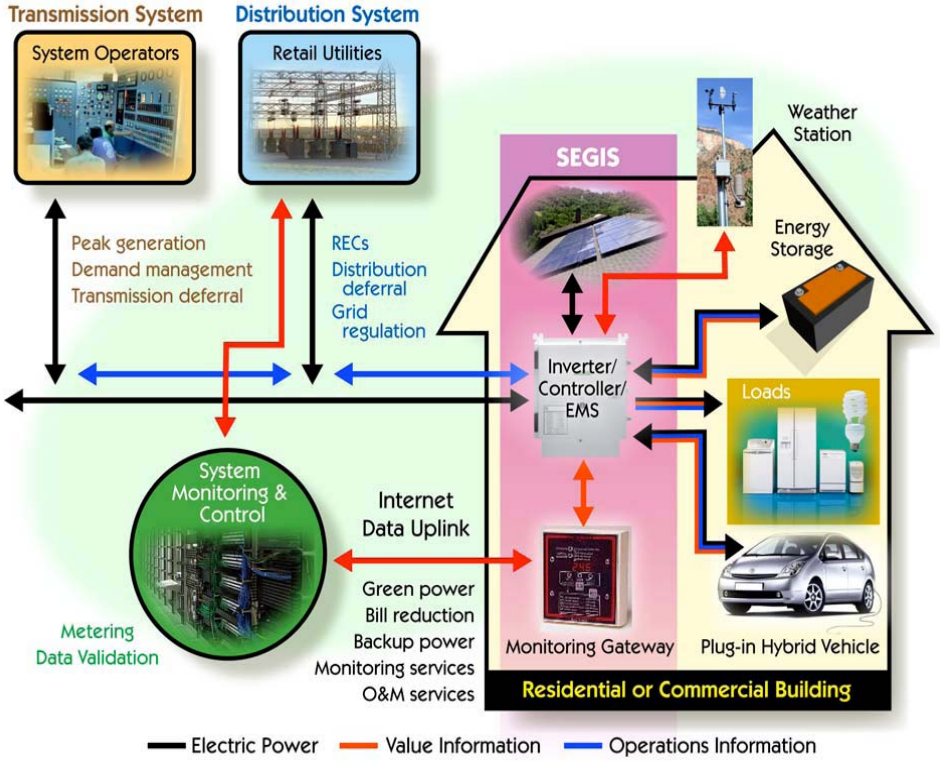
INTRODUCTION
"SEGIS" Overview

- The Needs
  - High PV Penetration
  - Grid Integration
  - Reliability/Lifetime
- The SEGIS Solicitation
  - Program Timeline
  - Program Logistics
  - Contractor Specifics
  - Technologies Overview
  - Solicitation Status
  - Next Steps
- Summary



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The Needs - "SEGIS" Program

- **"SEGIS" is an project under DOE's Systems Integration (SI) Program and Solar America Initiative (SAI) designed to**
  - **Fill R&D gaps in SAI Technology Pathways Partnership (TPP) agreements**
  - **Support DOE Solar Energy Technology program areas (Smart Grids, Energy Storage/Management)**
  - **Prepare for high-penetration of PV in the context of the future "Smart" utility grid**
    - Integrated Inverter/Controller
    - Integrated Energy Management and Storage
    - Advanced Communication

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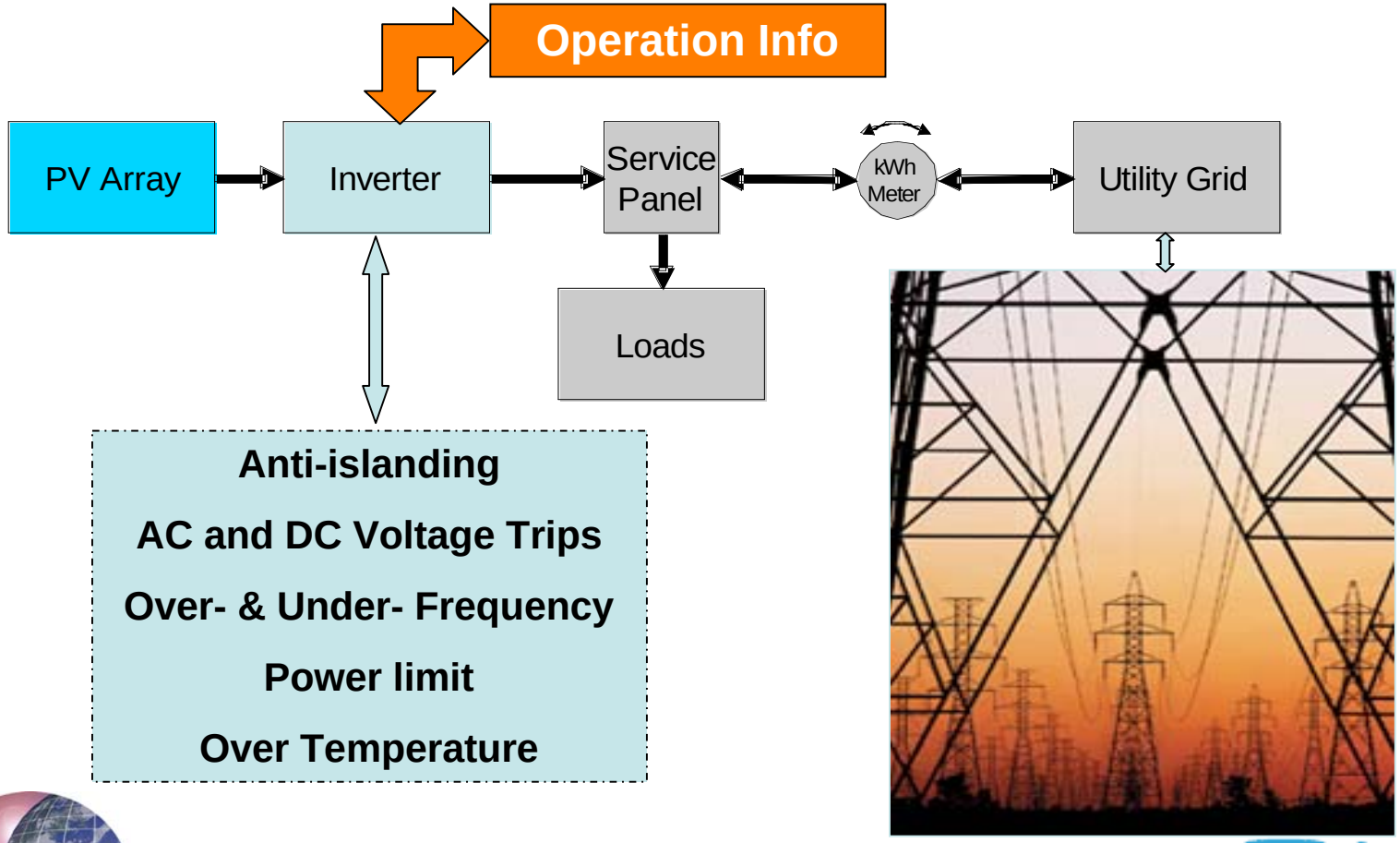
Today's Typical Utility Interconnection



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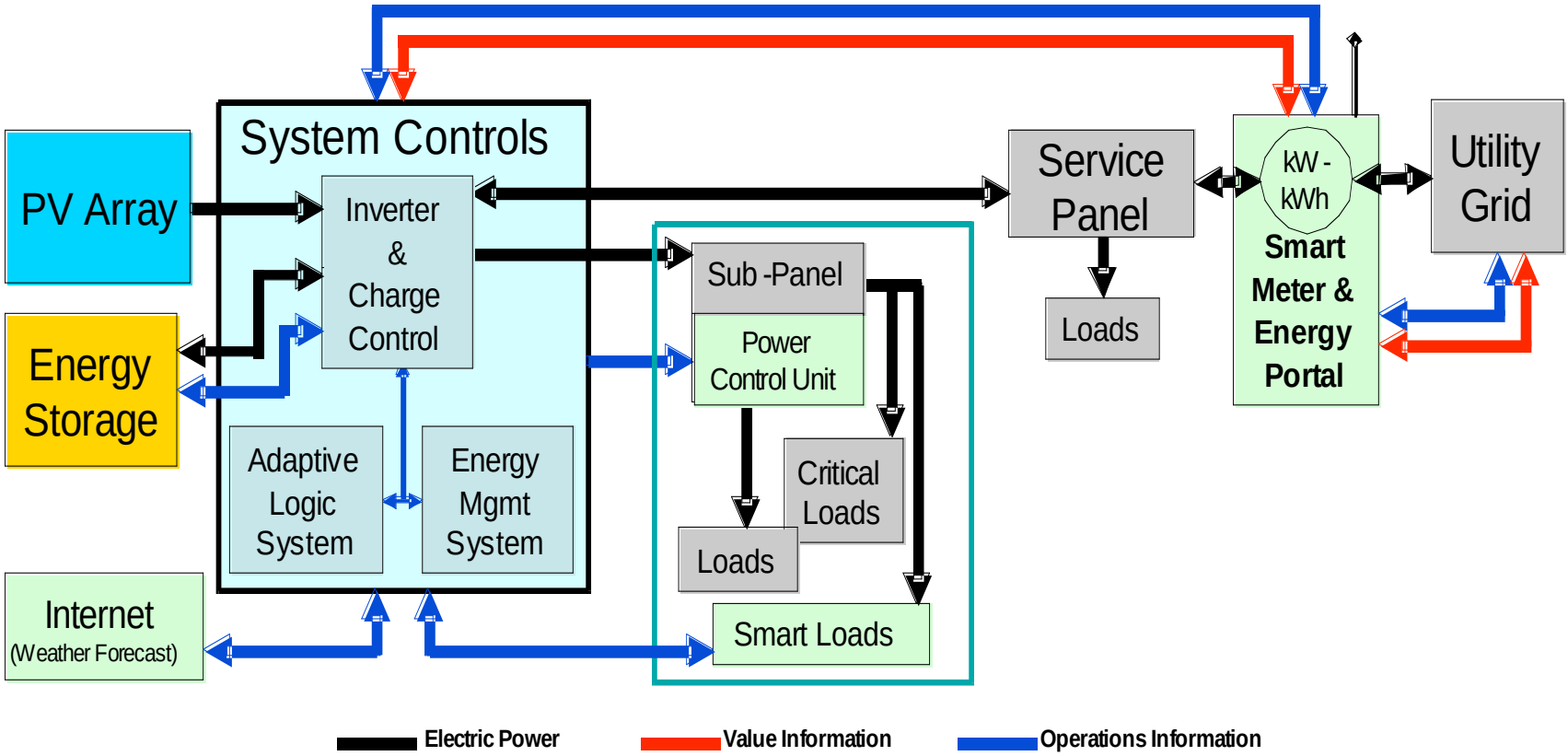
A Future Conceptual Intelligent Utility Interconnection



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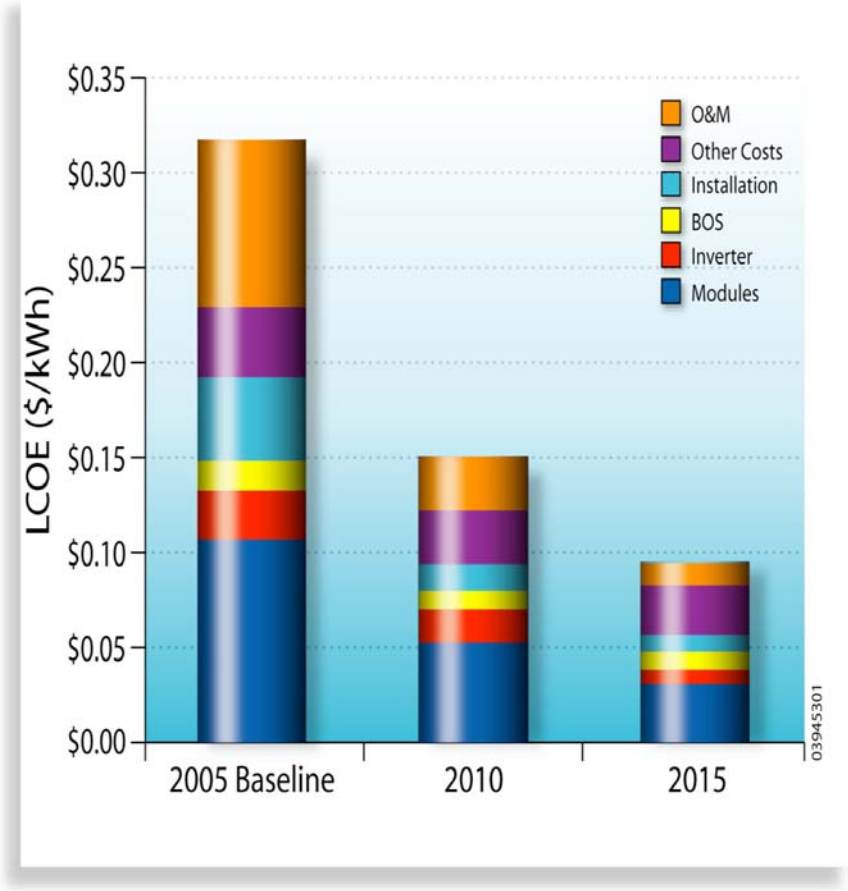
THE "SEGIS" VISION

ENABLE HIGHLY INTEGRATED, INNOVATIVE, ADVANCED INVERTERS, CONTROLLERS, CRITICAL BOS CONCEPTS & ENERGY MANAGEMENT FOR RESIDENTIAL AND COMMERCIAL PV APPLICATIONS



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"SEGIS" R&D Focus

- ***SIGNIFICANTLY*** **Advanced Inverters, Controllers and Energy Management Systems that maximize value to Utilities and Consumer**
- **Scope**
  - **PV Systems for High-value Residential and Commercial Applications (100W – 250kW)**
  - **PV Systems using Advanced Energy Management**
  - **Building/Structure PV Systems AND Hybrid/Micro-grid Applications that Utilize Energy Storage**
  - **Does NOT Include Development of PV Cell/ Module or Energy Storage Technology.**

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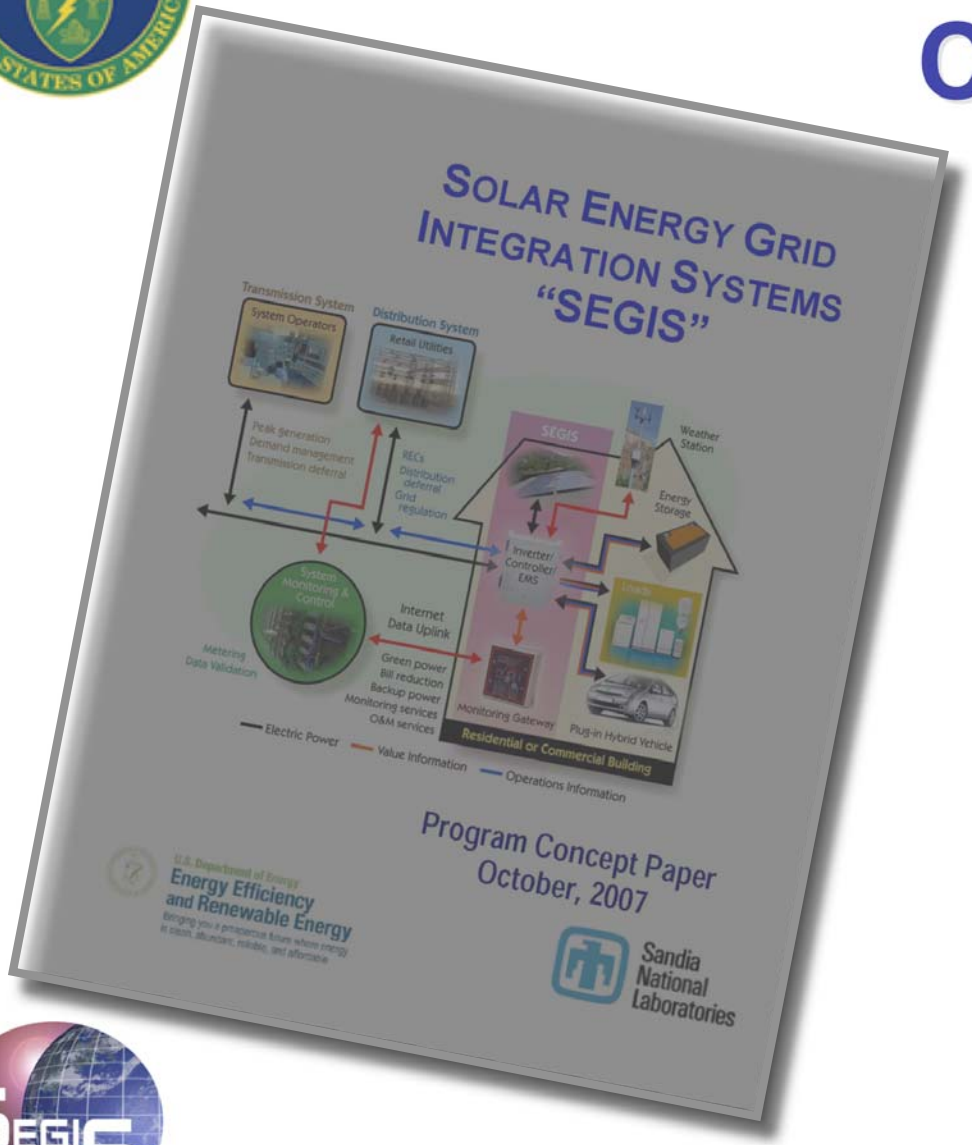
The "SEGIS" Concept Paper



- Captures the result of industry workshops that identified and prioritized technical issues related to high penetration PV
- Describes the goals and requirements of the SEGIS program
- Conveys detailed program requirements to prospective SEGIS solicitation participants

http://www.sandia.gov/SAI/files/SEGIS%20Concept%20Paper-071025.pdf

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The "SEGIS" Request For Proposals (RFP)

- **Three-year, three-stage cost-shared effort**
  - **Stage 1: Proof of concept & market analysis**
    - 9 months, 20% cost share with $250K maximum
  - **Stage 2: Prototype development**
    - 1 year, 20% cost share with $3M maximum
  - **Stage 3: Toward commercialization**
    - 1 year, 50% cost share with $3M maximum
- **Received 26 proposals, Selected 12 for Stage 1**
  - **Many Proposals Not Selected Were Technically Sound and Likely Candidates for R&D Funding**

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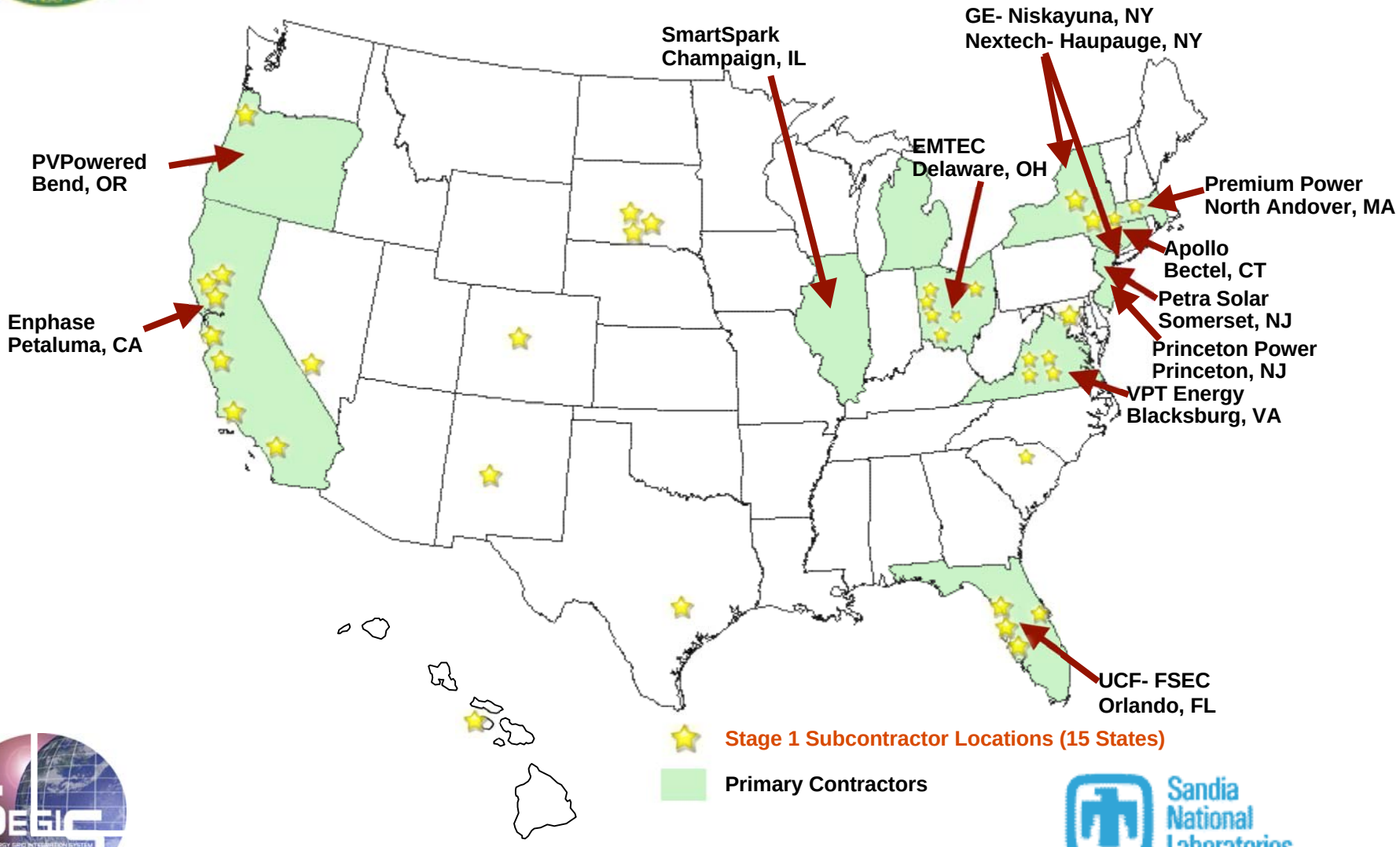
SEGIS Stage 1 Contractors & Team Members



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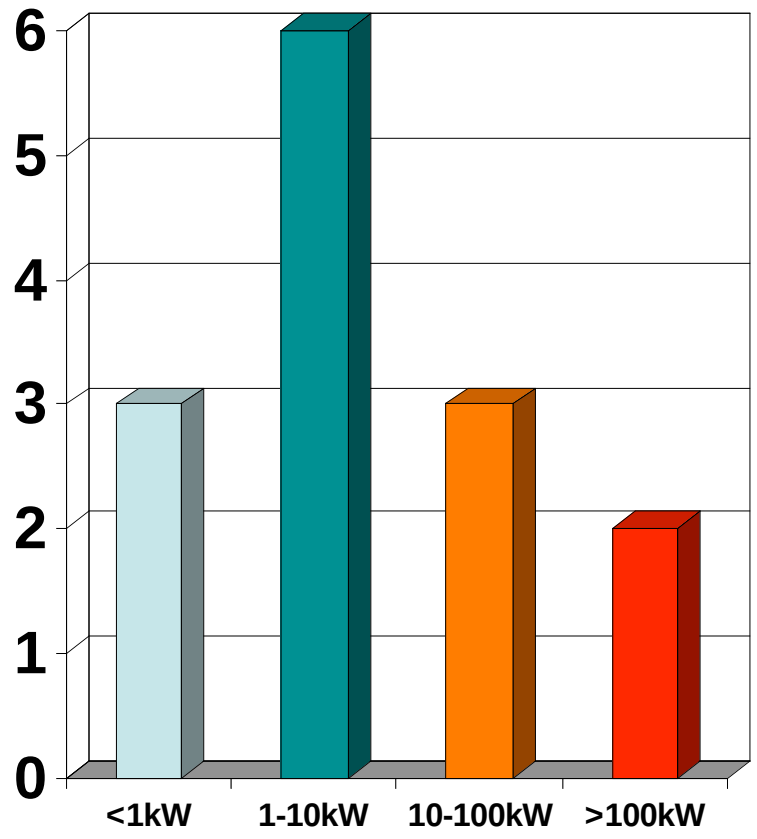
"SEGIS" Contracts- System Ratings



- <1kW Represents Micro-inverters
  - All are unique topologies
  - All are Integrated with PV modules
- 1 – 10 kW Represents Residential Systems
- 10 – 100 kW Represents Commercial Systems
- >100 kW Can be Commercial or Utility Systems

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"SEGIS" Contract - Commonalities

- All contracts include:
  - Inverter design or modification
  - Controller design
  - EMS
  - System Integration
  - Communications
  - Utility Support
- Proposed developments are likely to require changes in interconnection or other standards

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"SEGIS" Stage Process

Stage 1 – Proof Concept and Feasibility

SEGIS INITIAL PROPOSAL

- Stage 1 Complete Technical & Cost
- Stage 2 Complete Technical & Cost
- Brief Overview of Stage 3 Technical and Cost Proposal

Feasibility Analysis
(Market, Cost, Barriers)

Quarterly Reports

END OF SEGIS STAGE 1

- Stage 1 Technical Report
- Stage 1 Market Analysis Report
- Critical Program Review
- STAGE 3 DETAILED TECHNICAL & COST PROPOSAL)

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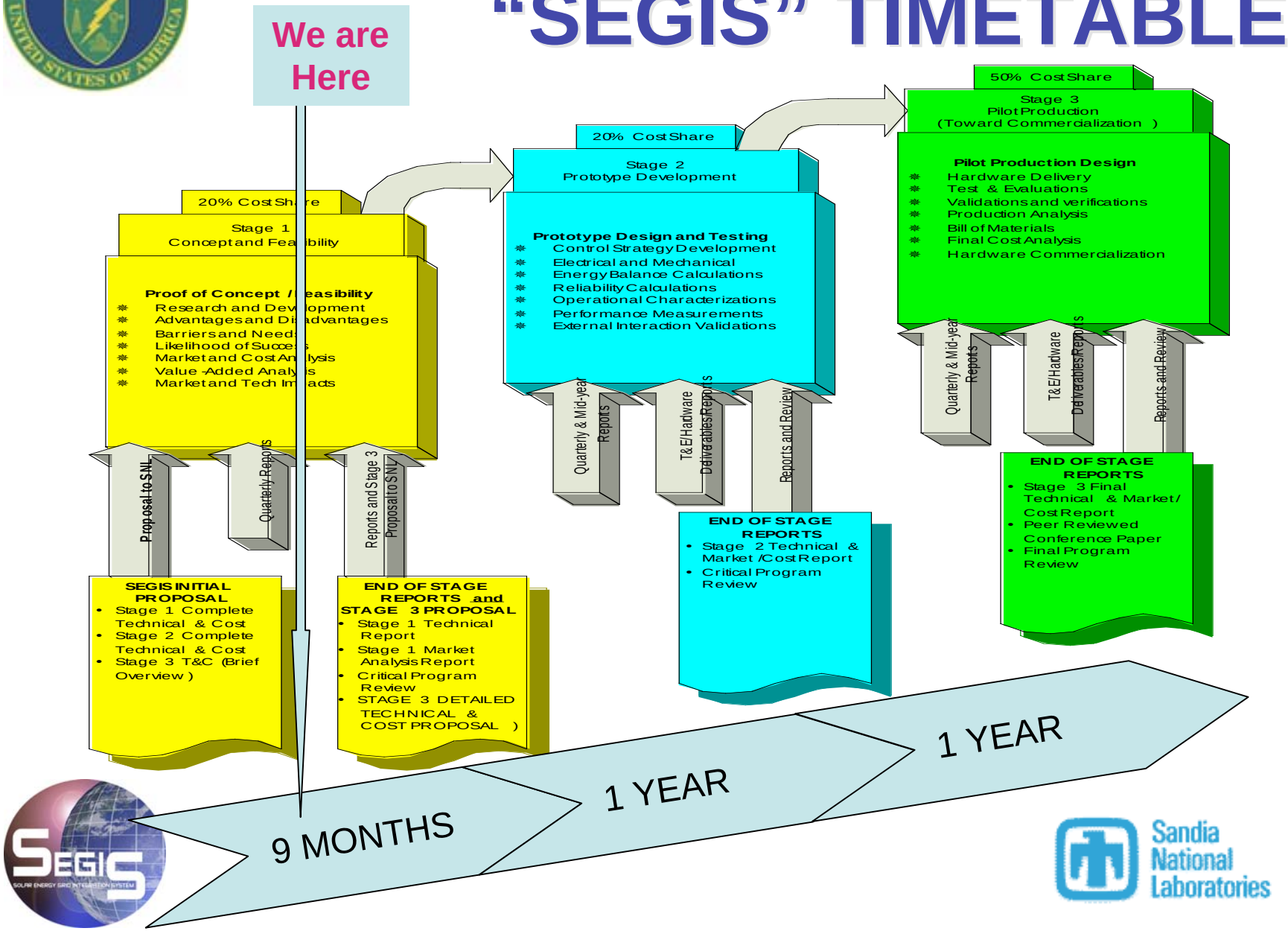
"SEGIS" TIMETABLE



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"SEGIS" FY09 Milestones

Milestones	CR	EN	Date
2) 2nd "Quarterly Reports" (12 Contractors)	X	X	12/12/08
3) DOE Solar Program Peer Review Presentations. (12 Contractors)	X	X	3/6/09
4) Final "Stage 1 Reports" (12 Contractors)	X	X	3/18/09
5) Critical Reviews (12 Contractors)	X	X	3/30/09
6) "Contractor Stage 1 Reviews" & Downsizing Determinations	X	X	4/2/09
7) Stage 2 downsize (?? Contractors)		X	5/9/09
8) 1st Stage 2 "Quarterly Reports"		X	9/1/09

- Solicitation progress posted on related DOE web pages (see last page for reference)

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The "SEGIS" Best Value Selection Criteria

- Criterion 1: **Meets Technical Objectives**
- Criterion 2: **Meets a Sound Technical Approach**
- Criterion 3: **Meets Project Management, Qualifications and Resource Needs**
- Criterion 4: **Provides a Viable Technology Deployment Plan**

(All criteria are based on the goals stated in the Solicitation)

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(Apollo Solar) *Advanced Grid-tied Inverter, Charge Controller, Energy Monitor & Internet Gateway*

Technologies Addressed

High efficiency Grid-tied Inverter System, Communications Portal, Charge Controller, Energy Management System

Description

Apollo Solar will develop advanced modular components for power conversion, energy storage, energy management and a portal for communications for residential solar electric systems. The inverters, charge controllers, and energy management systems will have provisions to communicate with utility energy portals for implementation of the seamless two-way power flows of the future.

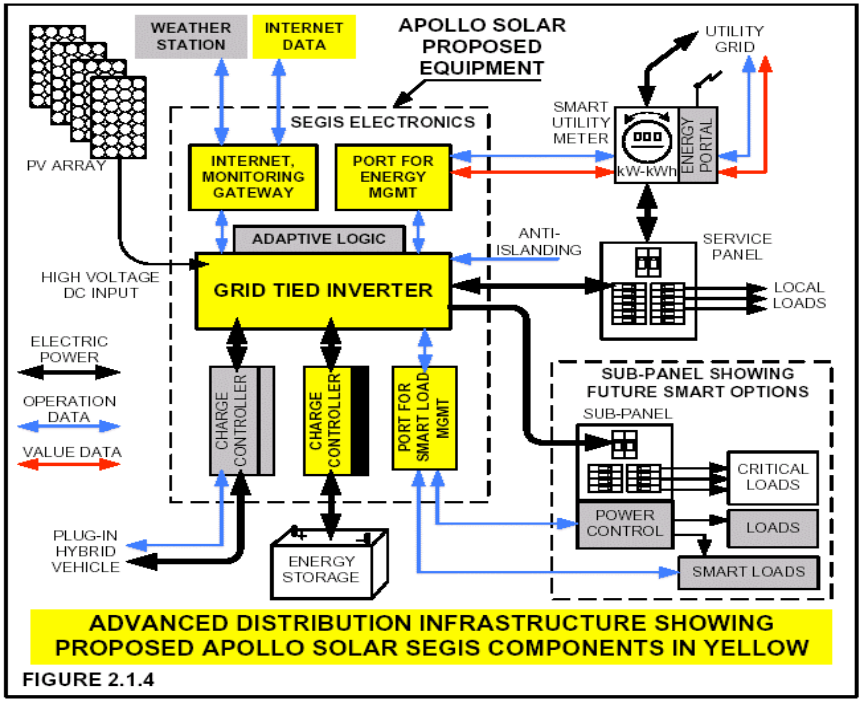

FIGURE 2.1.4

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**

Participants

Apollo Solar:
John Pfeifer

APOLLO SOLAR

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Edison Materials Technology Center (EMTEC)

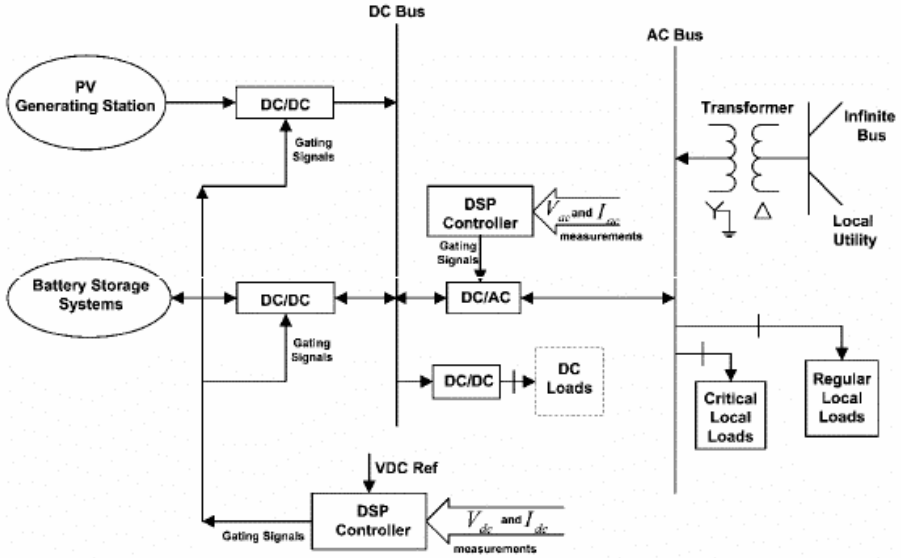
SEGIS - Emerson PV Inverter

Technologies Addressed

Large Scale Inverter (up to 2-MVA), Energy Storage, Energy Management, Integrated Controller

Description

EMTEC and its team will develop 3-phase, highly efficient, small footprint, innovative power conversion, energy storage and energy management components for commercial- and utility-scale PV systems. The R&D will create an integrated grid controller that works in conjunction with customer smart meters and that will respond to pricing signals to provide more predictable economics. Overall, the products will minimize fluctuations in electricity supply and demand.



Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**

Participants

Lead **Emerson Network**	Liebert Corporation	EMERSON Network Power
Jon VanDonkelaar (EMTEC)	K&H Energy Services/ Hull and Associates	K&H Energy Services, A division of Hull & Associates, Inc.
EMTEC	Ohio State Univ.	The Ohio State University

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(Enphase Energy) *Nano-inverter, VAr Control, & Energy Management System Methodologies*

Technologies Addressed

High efficiency Nano-inverters, Control Modules, Integrated System, Energy Management, VAr Compensation.

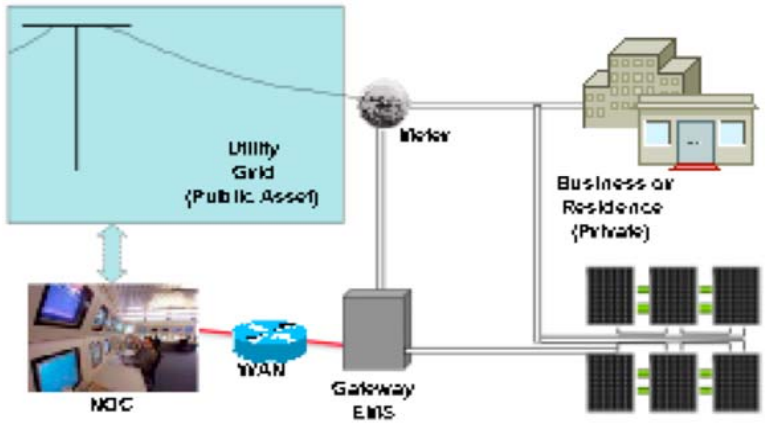
Description

Enphase Energy and its team will develop a complete module-integrated solar electric solution managed by an energy management system (EMS). The EMS will also interface with utilities to allow advanced control for modular utility-interactive applications.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**

Nano-inverters and EMS



Participants

Lead **Enphase Energy, Inc.**	Several PV Module Manufacturers Have Contacted Enphase.	[e] enphase ENERGY
Dr. Steve Sheppard		

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(General Electric Global Research)

Grid Integration of High-penetration Solar Energy

Technologies Addressed

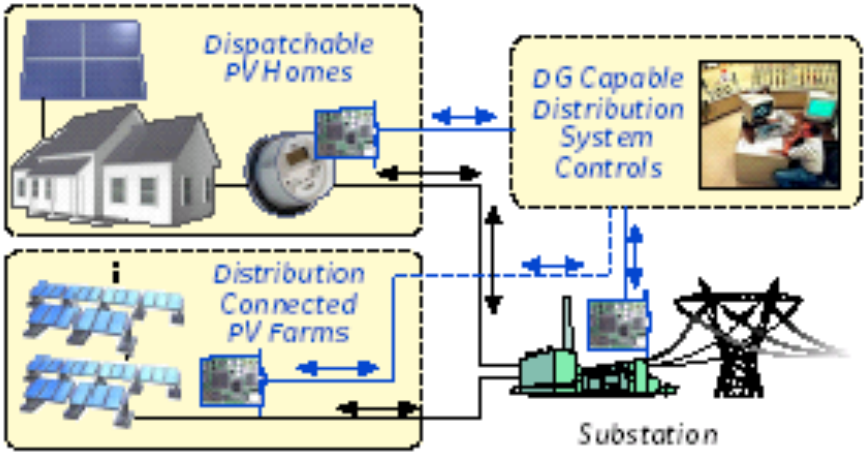
Advanced Inverter Controls, Energy Storage, Demand Response, Residential Energy Management, Utility Distribution Automation

Description

GE will advance residential PV generation coordination with energy storage, responsive loads, and demand side management programs. Grid connectivity to meet anticipated new requirements for enhanced three-phase inverter controls and distribution system controls will be improved.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**



Participants

Lead **General Electric**	Sentech	GE Global Research *Technology Development*
	NM Tech	SENTECH, Inc. *Marketing Analysis*
Rayette Fisher	AEP	New Mexico Tech *System Simulation and Validation*
	Duke	

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(Nextek Power Systems) *Advanced PV Interface*

Providing Concurrent AC & DC Power Network Support

Technologies Addressed

Direct Coupling® Where DC Power Sources Directly Serve DC loads, Bi-directional Energy Gateway, System Control

Description

Nextek will modify an existing power gateway design to incorporate bi-directional current flow, higher voltage, and added functionality including integrated communications and energy management for value-added PV utility interconnection and micro-grid applications. The advances will improve the Levelized Cost of Electricity (LCOE) of commercial systems while expanding applications for grid interconnection and energy management.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**

Participants

Lead **Nextek**	**Houston Advanced Research Center (HARC)** *Non-profit scientific organization to help bring products to market*	NEXTEK Power Systems Inc.

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(Petra Solar) *Economically Viable, Highly Integrated, Highly Modular SEGIS Architecture*

Technologies Addressed

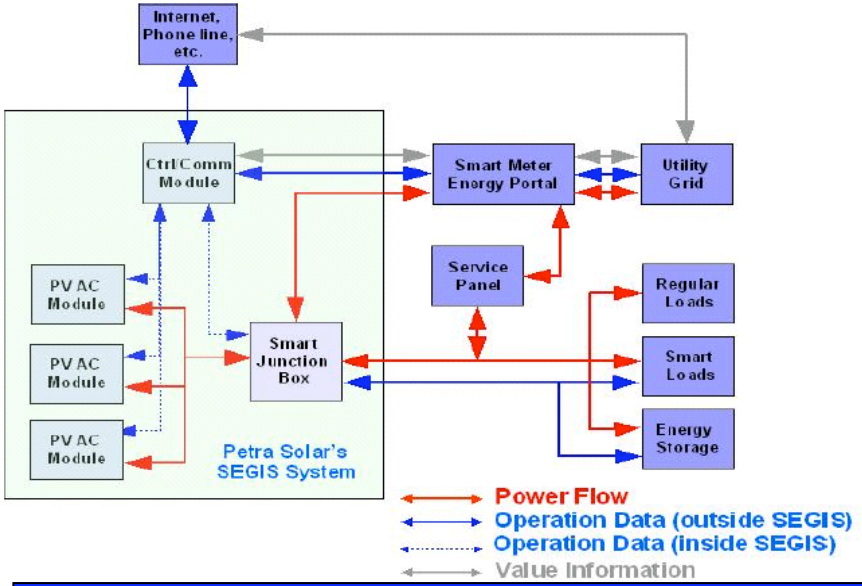
Smart Grid Interconnection, System Cost, Modularity, System Reliability, Safety, and Advanced Scalable Inverters

Description

Petra Solar will advance grid interconnection, cost reductions, system reliability, and safety through low cost, easy-to-install, modular and scalable inverter power architectures that are scalable from 5kW to 20kW. Advances include multi-layer control, communication architecture, monitoring and controlling a cluster of AC module inverters, and a strategic EMS switch junction box.

Resources ($)

DOE Max (3 stages)	DOE Stage 1	Cost Share (total)
$6,250K	**$250K**	**20% - 20% - 50%**



Participants

Lead	
Petra Solar	**Florida Power Electronics Center** **Florida Solar Energy Center** **Lakeland Electric** **Echelon** **BP Solar** **Evergreen Solar**
Adje Mensah	

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(Premium Power Corporation)

Intelligent PV Inverter

Technologies Addressed

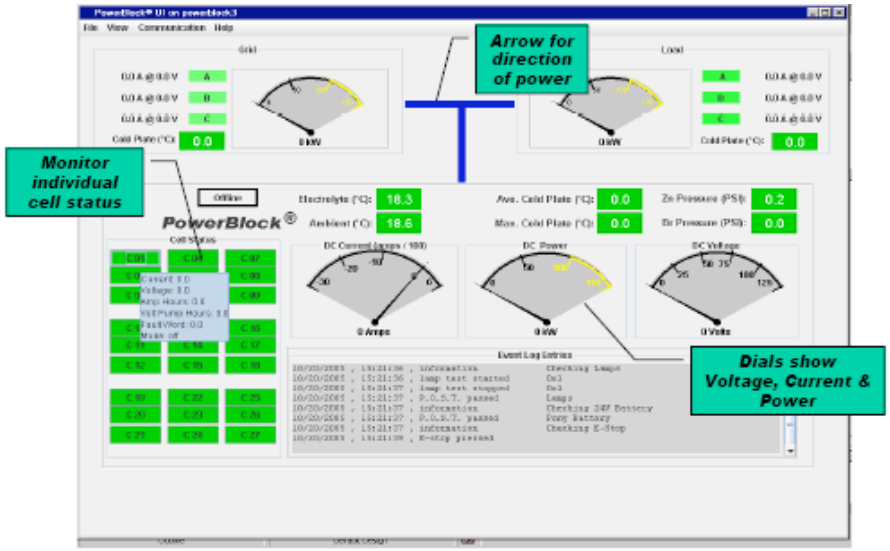
Intelligent PV system, Energy Management and System Optimization.

Description

Premium Power will develop an inverter system that makes PV economically viable in terms of investment cost, operating cost, and system lifetime. An intelligent PV system for commercial and utility scale applications with an advanced inverter having energy management and optimization capabilities for high values of solar energy will be developed.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**



Participants

Lead	Utility Partners have been contacted	
Premium Power		
William O'Donnell		

Premium Power

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(Princeton Power Systems)

Demand Response Inverter

Technologies Addressed

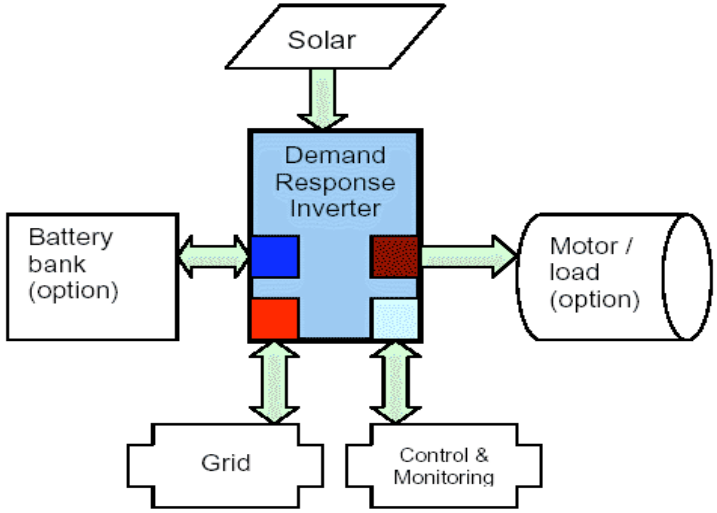
Demand Response Inverter, Load Control, Energy Storage, High Efficiency Components, Grid Integration.

Description

Princeton Power will develop a complete design for a 100-kW "Demand Response Inverter" based on its unique inverter technology. The design will be optimized for low-cost, high-quality manufacture, and will integrate control capabilities including dynamic energy storage and demand response through load control.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**



Participants

Lead		
Princeton Power Systems, Inc.	**TDI Power Corp.** **Worldwater and Solar Technologies** **Gaia Power Technologies**	

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(PVPowered) *Maximum Power Point Tracking, Advanced EMS and Utility Integration*

Technologies Addressed

Optimized Performance Algorithms, Advanced Data Collection, Communications and Energy Management Systems (EMS)

Description

PV Powered will develop a suite of maximum power point tracking (MPPT) algorithms to optimize energy production from the full range of available and emerging PV module technologies. The work will also develop integration of communications with facility energy management systems and utility grid management networks.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**

Participants

Lead **PVPowered**	**Portland General Electric Team**	**Northern Plains Power Technologies**
Dr. Steve Hummel	**South Dakota State University**	

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(SmartSpark) *Alternating Current PV Module with System Interface*

Technologies Addressed

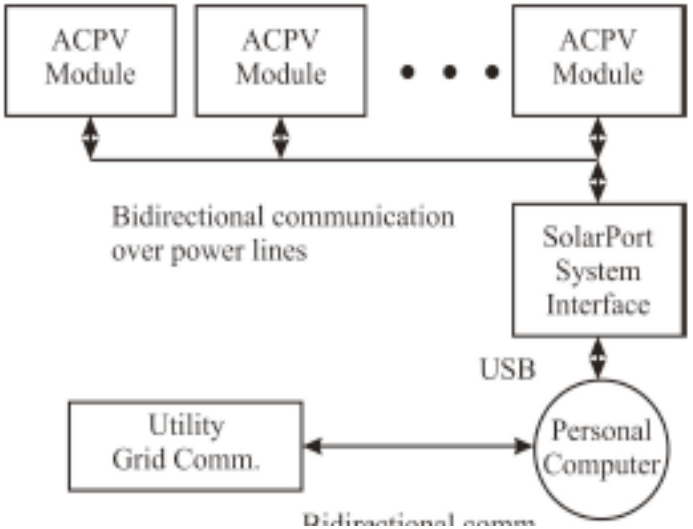
AC PV Module, Grid Integration Interface, Diagnostics, Data Logging

Description

SmartSpark will design, construct, test, and commercialize an alternating-current photovoltaic (ACPV) module with a grid-integration system interface. The ACPV module will be accompanied by an advanced system interface that provides system diagnostics, performance, data logging, and utility interconnection.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**



Participants

Lead **SmartSpark** Jeff Layton	**Evergreen Solar** **Innovolt Inc.**	SMARTSPARK ENERGY SYSTEMS

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(Florida Solar Energy Center at UCF)

Development, Validation and Commercialization of Grid-Smart Inverters for Wider PV Technology Utilization

Technologies Addressed

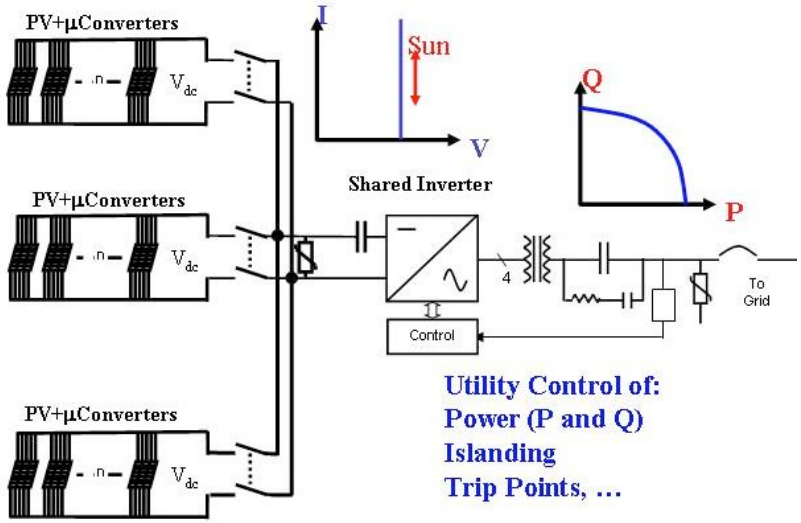
Utility Control of Enhanced Inverter Features, Disturbance-tolerant Anti-Islanding, Shared Inverter, Energy Storage, Building Interaction

Description

The FSEC and UCF team will develop new concepts and enhance "Smart Grid" development. A "shared" inverter serving multiple residential or commercial PV arrays located at a distribution transformer will be developed. Work includes battery storage, utility control, communication, monitoring, or building energy management systems (BEMS). An "anti-islanding" strategy that allows PV on line during grid disturbances will improve grid stability. New inverter architectures will bring more stability to the grid.

Resources ($)

DOE Max (3 stages)	DOE Stage1 (max)	Cost Share per stage
$6,250K	**$250K**	**20% - 20% - 50%**



Participants

Lead **University of Central Florida**	**SatCon**	**Northern Plains Power Technologies**
	SENTECH Inc.	
	EnFlex	**Lakeland Electric Utilities**
Robert Reedy (FSEC/UCF)	**SunEdison**	

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A RESEARCH INSTITUTE OF THE UNIVERSITY OF CENTRAL FLORIDA

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(VPT Energy Systems) *Inverter Control, Vehicle-to-Grid Integration using Bidirectional Power Converter, and Integrated Power Hub and Power Hub Controller*

Technologies Addressed

Vehicle integration with grid systems, Bi-directional Power Inverter/Rectifiers, Integrated Systems for Distributed Resources

Description

VPT and its team will develop components and overall system designs for integrated energy systems that include plug-connected vehicles and distributed energy resources. The R&D includes: controllers that add sophisticated grid interoperability, active anti-islanding including intentional islanding control to existing inverters; a bidirectional power converter designed for plug-connected vehicles; and integration systems for DC/AC grid-interactive distributed energy resources such as solar and wind.

Resources ($)

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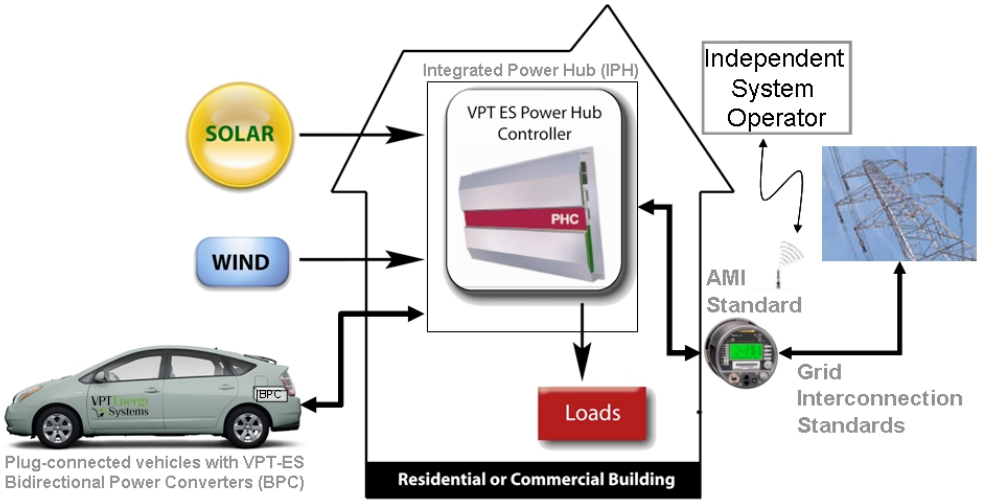
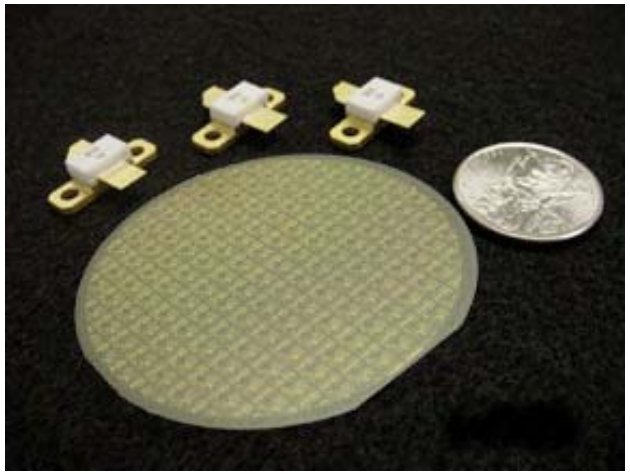


Participants

Lead	Team Members	
VPT Energy Systems	**Center for Power Electronic Systems at Virginia Tech**	**Solar Connexion**
		Breakell Inc.
Dr. Glenn Skutt	**Plug-In Conversions Corp.**	**Delta Electronics**

Advanced Component Applications Through the "SEGIS" Program

- Advanced Semiconductor Uses
- Highly-integrated Custom ICs
- Integrated Communication
- Micro-grid Controls & AMI
- MEMs & SiC Applications
- Integrated Cooling/Packages
- Advanced Surge Suppression
- Diagnostics/Gateways
- Interactive Monitoring
- Innovative Packaging
- Internal Protection/Longevity
- Magnetic Materials
  - Lower cost, higher performing
  - Planar & integrated devices
  - Nano-crystalline materials



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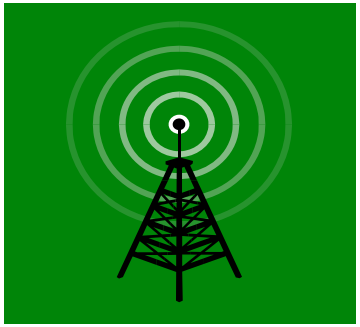
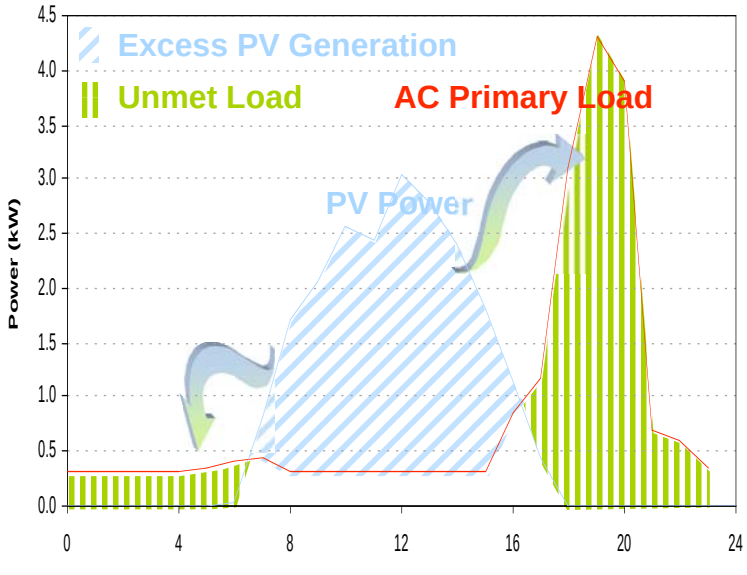
Advanced Methodology Applications Through the "SEGIS" Program

- **Energy Management and Communications Methods**
  - I/O protocol
  - Wireless/PLC/Ethernet/
  - Value-added Sensors/Detection to Improve Utility Acceptance
  - Advanced communications devices, sensors and methodologies
  - Integration with Storage





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"SEGIS" Near Term Spin-off Applications

- Future Solar America Cities Programs
- Critical State Supported Demonstration Generation Programs
- Joint Utility/Industry Programs to Meet Renewable Mandates
- Intermittency Mitigation with Energy Storage
- Residential PV Developments
- PIHV Applications
- Micro-grid Installations

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Inverter/Controller/BOS/EMS Next-Generation Logistics Needs

- **Device & System Self-protection/Reliability**
  - **Hardware and software advances to protect the inverter and components for high reliability**
  - **Advanced systems to Predict System Status/health/lifetime**
- **Improved Inverter AND System Modeling to Facilitate Advanced Adaptive Controls**
- **Customer Friendly Layout, Aesthetics, Mounting**

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Summary

- ***Advanced Integrated Inverters and Energy Management that Meet SAI Goals are being funded through SEGIS***
- ***Inverters/controllers/BOS/Storage will likely be elevated to system control and energy management***
- ***Inverters/controllers are becoming more complex, but reliability & costs must continue to improve***
- ***Further SEGIS advances will enable HIGH PENETRATION of PV using energy storage and micro-grid controls/optimization***

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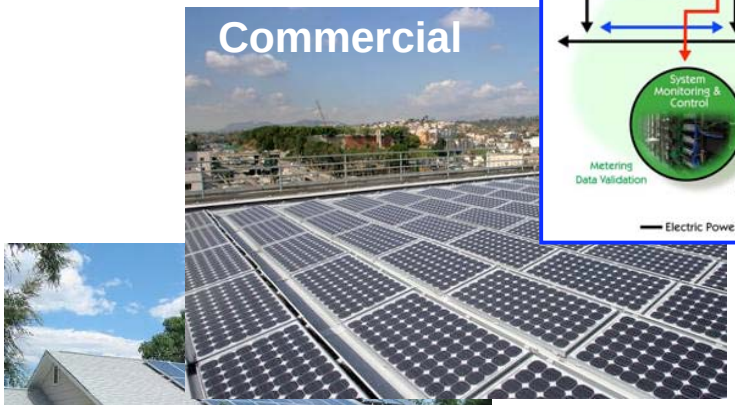
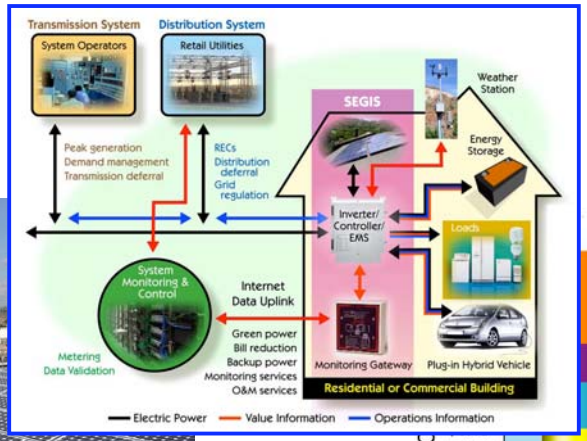
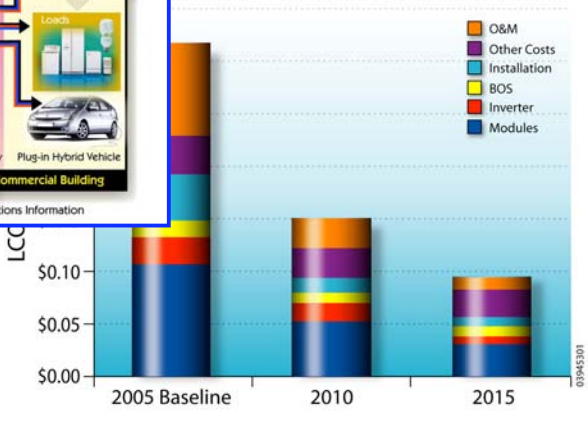
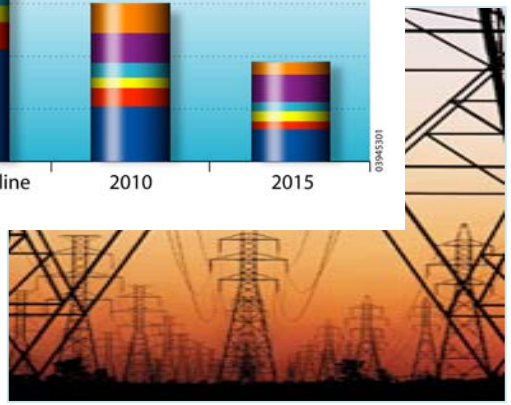
THANK YOU!









References:

http://www1.eere.energy.gov/solar/systems_integration_program.html

http://www.sandia.gov/solar/

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